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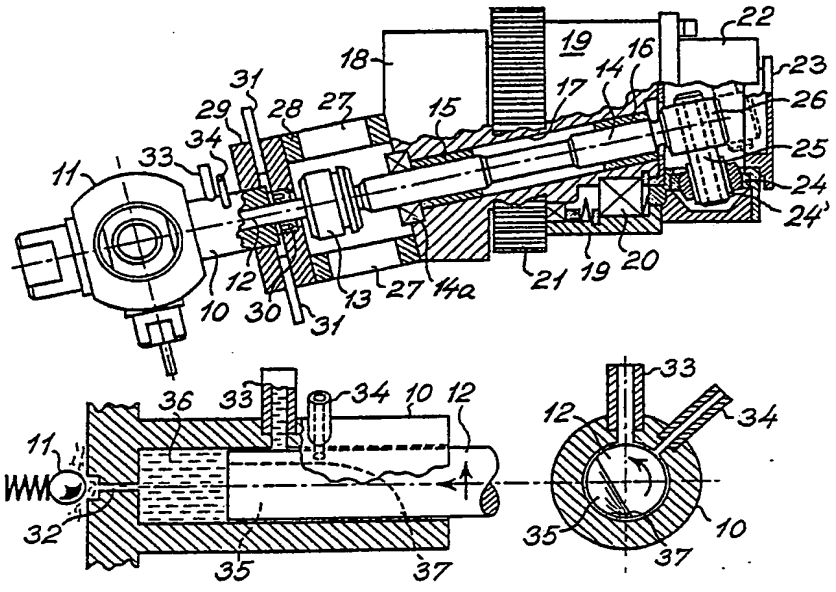
(54) Title: A ROTARY PISTON PUMP

(57) Abstract

A rotary piston pump comprising a pump cylinder (10) and a reciprocatable piston (12) may, for example, be used for pumping milk samples through a homogenizing valve unit (11) of a milk analyzing apparatus. In order to make the pump self-priming the cylinder is provided with a venting passage (34) by means of which the pumping chamber (36) is briefly communicated with the atmosphere when the piston is at its inner position or top position, whereby a possible compressed volume of air is removed from the pumping chamber. The pump is of the type in which the piston (12) is simultaneously reciprocated and rotated in the cylinder (10), and the piston is provided with an axially extending recess (35), so that the piston may also serve as a valve member opening and closing the venting passage (34) as well as a liquid inlet passage (33) through which liquid is sucked into the pumping chamber (36) during the suction strokes of the piston.



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# A ROTARY PISTON PUMP.

The present invention relates to a rotary piston pump and especially, but not exclusively, to a high pressure pump having a liquid discharge passage which is provided with a one-way valve.

This one-way valve or non-return valve is adapted so as not to open the liquid discharge passage, until a very high pressure has been created within the pumping chamber defined by the piston within the pump cylinder. However, such a high pressure piston pump has the disadvantage that it is not self-priming. When air or gas has collected within the pumping chamber, a pressure which is sufficiently high to open the one-way valve in the discharge passage can normally not be obtained during the pressure stroke, and during the succeeding suction stroke the compressed air will reexpand, which means that no liquid is sucked into the pumping chamber. As an example, high pressure piston pumps are used as homogenizing pumps for homogenizing milk samples in milk analyzing apparatuses, wherein the said one-way valve may function as a homogenizing valve. Such a homogenizing pump is for example disclosed in US patent No. 4,236,075. In this known apparatus the problem regarding the lacking self-priming ability of the homogenizing pump is solved thereby that the pump is not functioning as a high pressure pump during the first pressure strokes succeeding the sucking in of a new sample when air may be present within the cylinder. Thus, electrically controlled valves cause the first part of each sample to be pumped to a waste container without counterpressure, whereby air is removed from the inlet passage and the pumping chamber. Thereafter a remaining part of the liquid sample is pumped through the homogenizing valve under high pressure.

US patent No. 3,936,244 discloses a fuel pumping apparatus for supplying fuel to the cylinders of an internal combustion engine. The discharge passage of this pumping apparatus is formed within a rotary distributor member 11 which is driven by the associated engine, and which is adapted to communicate the discharge passage

with a venting passage during the pressure strokes of the piston. This venting passage contains a spring loaded valve member and is normally closed by a threaded plug, which must be unscrewed when the pump is to be vented.

The present invention provides a rotary piston pump which is self-priming even when it is operated at high pressures.

The pump according to the present invention is of the type comprising a cylinder, a piston movably arranged within the cylinder so as to define a pumping chamber therein, and driving means for reciprocating the piston through successive suction and pressure strokes during which liquid is sucked into the pumping chamber through an inlet passage and discharged therefrom through a discharge passage, respectively, and for simultaneaously rotating the piston so as to communicate the pumping chamber with the inlet passage during each suction stroke and disrupt that communication during each pressure stroke of the piston, and the pump according to the invention is characterized in that the driving means are adapted to move the piston in the cylinder so as to briefly establish communication between the pumping chamber and a venting passage during the last part of each pressure stroke of the piston.

When gas or air is present within the pumping chamber, it will become compressed without reaching a pressure which is sufficiently high to open the one-way valve of the discharge passage. The brief communication established between the pumping cylinder and the venting passage at the end of the pressure stroke causes the major part of the air or gas to escape from the cylinder chamber, so that liquid may be sucked into the pumping chamber during the succeeding suction stroke. When all or substantially all of the air or gas has been vented from the pumping chamber, the desired high pressure which is able to open the one-way valve, may be obtained within the pumping chamber. Because liquids are substantially incompressible, the fact that the pumping chamber is communicated with the venting opening for a

very short moment at the end of each pressure stroke, does not have any disadvantageous effect on the normal function of the pump.

In the pump according to the present invention the venting passage is opened and closed by the rotary piston, which functions as a valve member, whereby a rather simple and reliably structure is obtained. In a preferred embodiment the piston also functions as a valve member controlling the liquid inlet passage of the pump, and the piston must consequently be provided with suitable bores, passages, and/or channels for performing its valve functions. Thus, according to the invention a longitudinally extending recess communicating with the pumping chamber may be defined in the peripheral surface of the piston, said driving means being adapted to briefly register the recess with the venting passage during the last part of its pressure stroke. The piston may have an additional recess or passage for communicating the liquid inlet passage with the cylinder chamber during the suction strokes of the piston. It is preferred, however, to use the same recess for controlling the venting passage as well as the liquid inlet passage.

The recess in the piston may have a narrow or pointed end part, and the venting passage may open into the wall of the cylinder at such a location that the pointed end part of the recess is registered with the venting opening at its pointed end part. Because the pointed end part of the recess has a very small peripheral width, the time period in which communication is established between the pumping chamber and the venting passage will be very short as desired, and the venting passage is closed, before the succeeding suction stroke is initiated so that sucking of air into the pumping chamber through the venting passage is avoided.

The rotary piston pump according to the invention may be used for any suitable purpose. However, in the presently preferred embodiment it is used as a homogenizing pump in connection with

milk analyzing apparatuses, and in that case the one-way valve in the discharge passage of the pump is in the form of a homogenizing valve.

The homogenizing valve may then comprise a valve seat, a ball-shaped valve member, and an annular elastic sealing ring, for example an O-ring, biasing the valve member against the valve seat. When the necessary homogenizing pressure is relatively low, for example in the order of 50 atmospheres or less, the elastic pressure at which the valve member is biased against its seat may exclusively be generated by the sealing ring or O-ring, if desired. In other cases, where the homogenizing pressure is higher, the valve member is preferably pressed against its valve seat also by a displaceable, spring activated member. In both cases the annular sealing ring serves to reduce or suppress vibrations which tend to be imparted to the valve member during function of the homogenizing valve. Simultaneously, the annular sealing ring or O-ring functions to seal against the valve member, whereby the dead space of the homogenizing valve may be substantially reduced, whereby a smaller amount of liquid is required for purging or flushing the homogenizing valve when shifting from one milk sample to another. As part of the liquid or milk sample itself is normally used as purging liquid, the use of an annular sealing ring as described allows for use of smaller liquid samples.

In connection with a homogenizing pump two or more homogenizing valves, which are arranged in series, are often used. It is then preferred that the inner diameter of the annular sealing ring is substantially equal to the bore diameter or opening diameter of the valve seat, because transmission of possible vibrations of the valve member in one of the homogenizing valves to the valve member of a succeeding valve may then be prevented.

Even though the homogenizing valve described above may advantageously be used in connection with a rotary piston pump according to the invention, it may also be used in connection with oth r high pressure pumps, for example of known types.

The invention will now be further described with reference to the drawings, wherein
Fig. 1 shows a side view and partially sectional view of an embodiment of the rotary piston pump according to the invention,
Figs. 2 - 5 illustrate the operation of the pump, each of the figures showing diagrammatically a side view and partially sectional view, and a cross-sectional view of the pump cylinder and the piston arranged therein,
Fig. 6 shows a side view and partially sectional view of the rotary piston pump shown in Figs. 1 and 2 and of associated homogenizing valves, and
Fig. 7 shows a sectional view along the line VII-VII in Fig. 6.

The high pressure piston pump shown in the drawings is a homogenizing pump which may, for example, be used in connection with a milk analyzing apparatus of the type disclosed in US patent No. 4,236,075. The pump comprises a pump cylinder 10, which is connected to a homogenizing valve unit 11, and which contains a piston 12. The piston is connected to a piston rod 14 via a so-called "Olham-coupling" 13. The piston rod 14 is rotatably and axially displaceably arranged in bearing bushings 15 and 16, which are mounted in a bore 17 formed in a stationary frame part or apparatus part 18, see Fig. 1. A sealing ring 14a sealing surrounding the piston rod 14 is mounted at the left (Figs 1) end of the bore 17.

A driving mechanism for driving the piston 12 comprises a drum-like frame part 19 which is rotatably mounted on the stationary frame part 18 by means of a ball-bearing 20, and the drum-like frame part 19 comprises a toothed rim 21 which may be connected to a driving motor (not shown) by means of a toothed belt. A driving part 22 is screw-fastened to the right end of the rotatable frame part 19 and closed by means of a cover 24. A so-called joint bearing 24 is mounted within the driving member 22, and a shaft 25 is rotatably and displaceably mounted within the lining 24' of the bearing 24, and the end part of the shaft 25 extending from the bearing 24 is fixedly received in the bore of a

sleeve-like head 26 formed at the adjacent end of the piston rod 15. The pump cylinder 10 is fixed to the stationary frame part 18 by means of an intermediate part 28 provided with openings 27 and by means of a mounting block 29. The intermediate part 28 surrounds the coupling 13, and the mounting block 29 is provided with a piston gasket 30 and radially extending drainage tubes 31.

It is understood that when the rotatable frame part 19 and the driving part 22 connected therewith are rotated by means of the toothed rim 21, the joint bearing 24 and the shaft 25 are also rotated about the axis of the toothed rim 21. Because the shaft 25 defines an acute angle with the rotational axis of the rim 21, this rotational movement causes the piston rod 14 and also the piston 12 to reciprocate along its longitudinal axis, but also to simultaneously perform a rotational movement about its own axis.

As shown diagrammatically in Figs. 2 - 5 the homogenizing valve unit 11 in principle functions as a one-way valve or a non-return valve, which normally closes the liquid discharge passage 32 of the pump cylinder 10. The pump cylinder is also provided with a liquid inlet passage 33 and a venting passage 34. The piston 12 is provided with a milled recess 35 extending axially from the piston 12. This recess is shaped so that the piston may serve as a valve member controlling the liquid inlet passage 33 and the venting passage 34, when the piston perform its normal movements within the pumping cylinder, as will be explained more in detail below with reference to Figs. 2 - 5.

Fig. 2 shows the pump during a pressure stroke of the piston 12. The piston 12 is in such a rotational position that the recess 35 is facing away from the liquid inlet passage 33 and the venting passage 34, and, consequently, the communication between these passages and the pumping chamber 36 defined by the piston in the cylinder is interrupted. Therefore further movement of the piston 12 against its inner position or top position causes compression of the medium contained in the pumping chamber 36. If the pumping chamber 36 is complet ly filled with liquid, the pressure within the

chamber 36 very quickly reaches a level at which the homogenizing valve or one-way valve 11 is opened, so that liquid under the high pressure may be pressed from the pumping chamber 36, through the liquid discharge passage, and into the homogenizing valve unit. However, if the pumping chamber 36 contains gas or air to any substantial degree, such gas volume is compressed during the pressure stroke of the piston 12 without increasing the pressure within the pumping chamber sufficiently to cause the one-way valve or the homogenizing valve 11 to open. In conventional high pressure piston pumps of the type described the compressed gas or air volume will reexpand during the succeeding suction stroke. Therefore, during this suction stroke it is not possible to create a vacuum within the pumping chamber 36 which is sufficient to suck in liquid through the liquid inlet passage 33. For that reason such conventional pumps are not self-priming.

In the pump shown on the drawings this problem has been solved by the provision of the venting passage 34. The location of this venting passage, the shape of the recess 35, and the rotary movement of the piston 12 are chosen so that the opening of the venting passage into the cylinder will be uncovered very briefly immediately before or when the piston 12 reaches its inner position or top position. This situation is shown in Fig. 3. A possible compressed gas or air volume present within the pumping chamber 36 when the piston 12 is at its top position will then expand and flow out into the atmosphere through the venting passage 34. As indicated in the drawings the end part of the recess 35 opposite to the piston 12 has a pointed shape, and the venting passage 34 is preferably positioned so that it will be uncovered by the pointed end 37 of the recess 35 when or immediately before the piston reaches its inner position or top position. This means that the venting passage 34 is closed again by the initial small rotary movement of the piston 12 during the first part of the suction stroke.

Thus, the venting passage 34 will be closed during almost all of the suction stroke while the liquid inlet passage 33 will be

uncovered by the recess 35 in the piston. Consequently, the liquid inlet passage is communicating with the pumping chamber 36, whereby liquid is sucked into the pumping chamber through the liquid inlet passage 33 as illustrated in Fig. 4. When the piston 12 has reached its outer position or bottom position, it takes up such a rotational position that it closes the liquid inlet passage 33 as well as the venting passage 34, so that during the succeeding pressure stroke the medium present within the pumping chamber 36 may escape only through the one-way valve 11.

As the pumping chamber 36 is communicated with the atmosphere through the venting passage 34 each time the piston is in its top position, a possible amount of gas or air present within the pumping chamber 36 and/or the liquid inlet passage 33 will be removed during a few pressure strokes. Consequently, contrary to the known high pressure piston pumps, the pump according to the invention is self-priming. Liquid which might leak from the pumping chamber 36 past the piston 12 may be drained off through the draining tubes 31.

Figs. 6 and 7 show the homogenizing valve unit in detail. This homogenizing valve unit contains two homogenizing valves 38 and 39 connected in series. The homogenizing valve 38 has a valve seat 40 defining an opening forming a continuation of the liquid discharge passage 32 of the pump. A ball-shaped valve member 41 is pressed against the valve seat by means of a helical spring 42 which is arranged within a tubular spring housing 43 provided with external threads 43a and screwed into engagement with corresponding internal threads formed in a valve housing 44 common to two homogenizing valves. The outer end of the helical spring 42 is abutting a screw cover 45 which is screwed into the spring housing and by means of which the tension of the spring may be adjusted. The inner end of the spring is in-engagement with one end of a pressure transmitting pin 47 via a disc-shaped abutting member 46. The other end of the pin is in engagement with the ball-shaped valve memb r 41. The pin 47 extends through a guiding sleeve 48, and the inner end of the sleeve 48 engages

with an O-ring 49 which in turn is in engagement with the ball-shaped valv member 41. The guiding sleeve 48 is maintained in the desired axial position by means of a locking ring 50, which is screwed into the spring housing 43 and is in engagement with the outer end of the guiding sleeve 48. The inner end portion of the guiding sleeve is received in a bore formed in a part 51 of the housing containing the valve member 41. The part 51 as well as the valve seat 40 is maintained in position by the spring housing 43. The homogenizing valve 39 is of the same structure as the valve 38, and the parts of the valve 39 are indicated by the same reference numerals as the corresponding parts of the valve 38 but provided with '. The valves 38 and 39 are interconnected by a connecting passage 52. A liquid outlet passage 53 is formed in the housing part 51' of the homogenizing valve 39. This outlet passage 53 leads to a conventional non-return valve 54 which is screwed into the common valve housing 44 and communicating with a discharge conduit 55. As shown in the drawings, the housing parts 51 and 51' may be prevented from rotating in relation to the common housing 44 by means of pins 56 and 56' which are received in bores in the housing 44 so that their inner ends are extending into corresponding radial bores in the housing parts 51 and 51', respectively.

When liquid such as a milk sample, is pumped trough the two stages of the homogenizing valve unit 11 by means of the rotary piston pump under a high pressure, the milk sample will be homogenized in a manner known *per se*. The homogenizing valve 38 forming the first stage of the unit 11 may, for example, be adjusted so as to open the liquid discharge passage 32 of the pump at a pressure of about 120 atmospheres. At this pressure the ball-shaped valve member 41 is lifted a small distance from its seat by overcoming partly the pressure of the helical spring 42 transmitted by the pin 47, and partly the pressure exerted by the O-ring 49. This O-ring is preferably made from an elastic material having a certain inner friction, so that it is able to suppress vibrations which might be imparted to the ball-shaped valve member 41. Furthermore, the O-ring serves as a sealing member

preventing the liquid being pumped through the valve from leaking into the spring housing 43. The O-ring may, for example, be a standard O-ring marketed by the firm Mogens Christensen, Copenhagen, under the designation "R2007".

After having passed the homogenizing valve 38 the liquid continues through the connecting passage 52 to the homogenizing valve 39, which functions in the same manner as the homogenizing valve 38 apart from the fact that the valve 39 forming the second homogenizing stage normally operates at a lower homogenizing pressure, for example in the order of 50 atmospheres. The homogenized liquid leaves the homogenizing valve 39 through the outlet passage 53, the non-return valve 54, and the discharge conduit 55.

It should be understood that various modifications and changes of the embodiment shown on the drawings could be made within the scope of the present invention. Thus, the high pressure piston pump described may be used in connection with homogenizing valve units of a type other than that shown, or for any other purpose, for which a self-priming high pressure piston pump is desirable.

PATENT CLAIMS

1. A rotary piston pump for pumping liquid and comprising a cylinder (10), a piston (12) movably arranged within the cylinder so as to define a pumping chamber (36) therein, and driving means (19, 25) for reciprocating the piston through successive suction and pressure strokes during which liquid is sucked into the pumping chamber through an inlet passage (33) and discharged therefrom through a discharge passage (32), respectively, and for simultaneously rotating the piston (12) so as to communicate the pumping chamber (36) with the inlet passage (33) during each suction stroke and disrupt that communication during each pressure stroke of the piston (12),
c h a r a c t e r i z e d in that the piston driving means (19, 25) are adapted to move the piston (12) in the cylinder (10) so as to briefly establish communication between the pumping chamber (36) and a venting passage (34) during the last part of each pressure stroke of the piston.

2. A piston pump according to claim 1,
c h a r a c t e r i z e d in that a longitudinally extending recess (35) communicating with the pumping chamber (36) is defined in the peripheral surface of the piston (12), and that the piston driving means (19, 25) are adapted to briefly register the recess (35) with the venting passage (34) during the last part of each pressure stroke.

3. A piston pump according to claim 2,
c h a r a c t e r i z e d in that the recess (35) has a narrow or pointed outer end part (37), and that the venting passage (34) opens into the wall of the cylinder (10) at such a location that the pointed end part (37) of the recess (35) is registered with the venting opening at its pointed end part.

4. A piston pump according to any of the claims 1 - 3,
c h a r a c t e r i z e d in that the discharge passage (32) is controlled by a one-way valve which is a homogenizing valve (11).

5. A piston pump according to claim 4, c h a r a c t e r i z e d in that the homogenizing valve comprises a valve seat (40), a ball-shaped valve member (41), and an annular elastic sealing ring (49) biasing the valve member against the valve seat.

6. A piston pump according to claim 5, c h a r a c t e r i z e d in that the sealing ring is an O-ring (49).

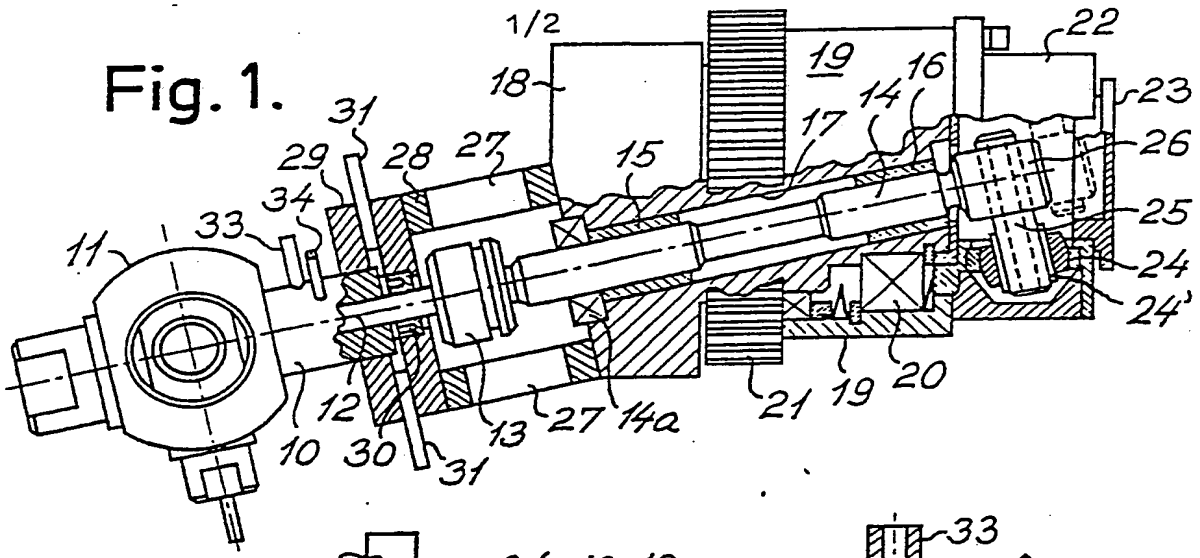
7. A piston pump according to claim 5 or 6, c h a r a c t e r i z e d in that the valve member (41) is pressed against its valve seat (40) also by a displaceable, spring-actuated member (47).

8. A piston pump according to claim 7, c h a r a c t e r i z e d in that the spring-actuated member (47) extends through the opening of the annular sealing ring (49) and is in direct contact with the valve member (41).

9. A piston pump according to claim 8, c h a r a c t e r i z e d in that the spring-actuating member is a pin-like member (47) displaceably mounted in a bore (48) aligned with the opening of the sealing ring (49).

10. A piston pump according to any of the claims 1 - 9, c h a r a c t e r i z e d in that the inner diameter of the annular sealing ring (49) is substantially equal to the bore or opening diameter of the valve seat (40).

Fig. 1.



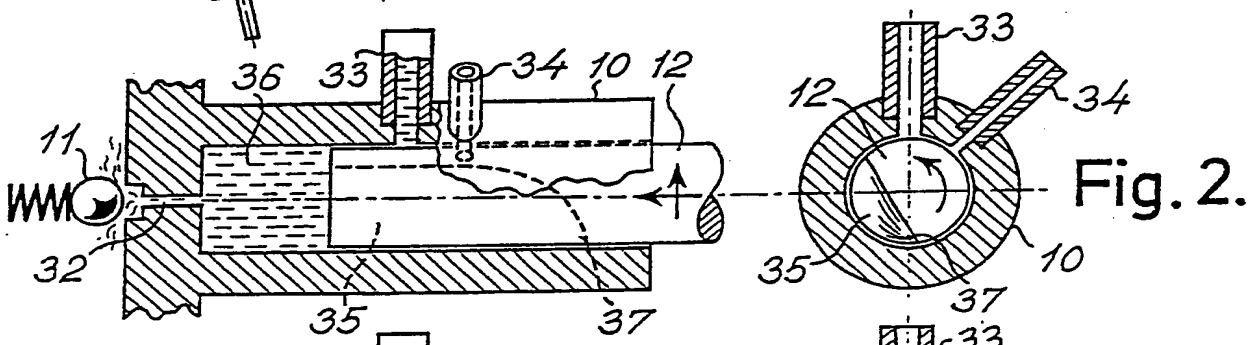




Fig. 2.

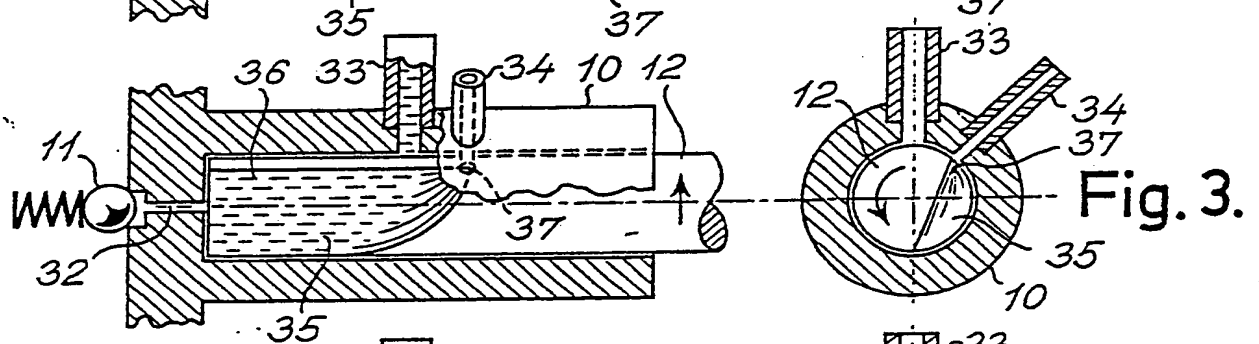



Fig. 3.

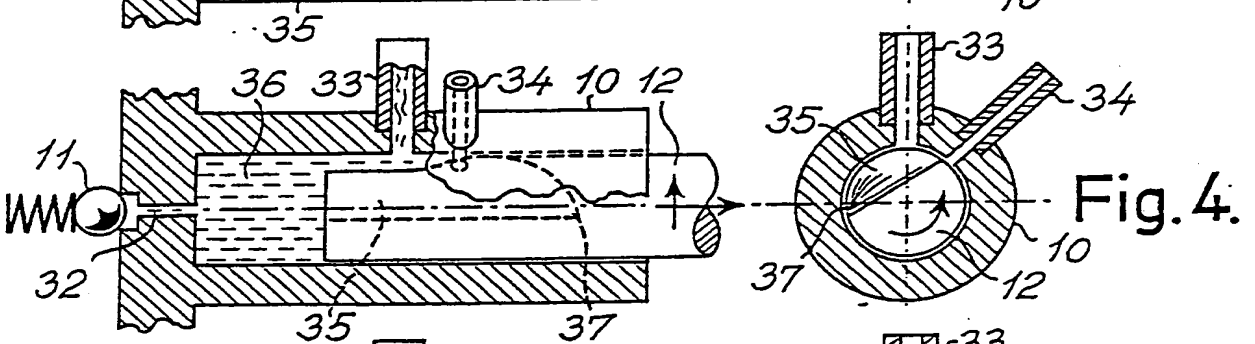



Fig. 4.

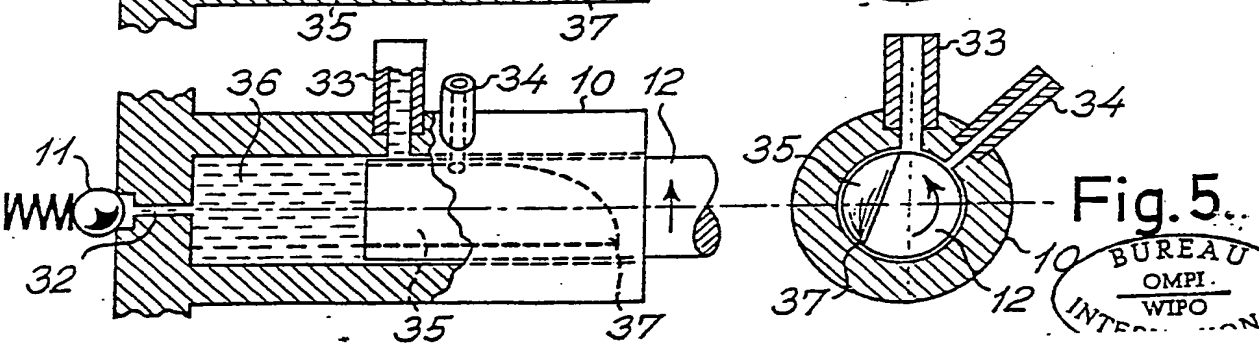



Fig. 5.

Fig. 6.

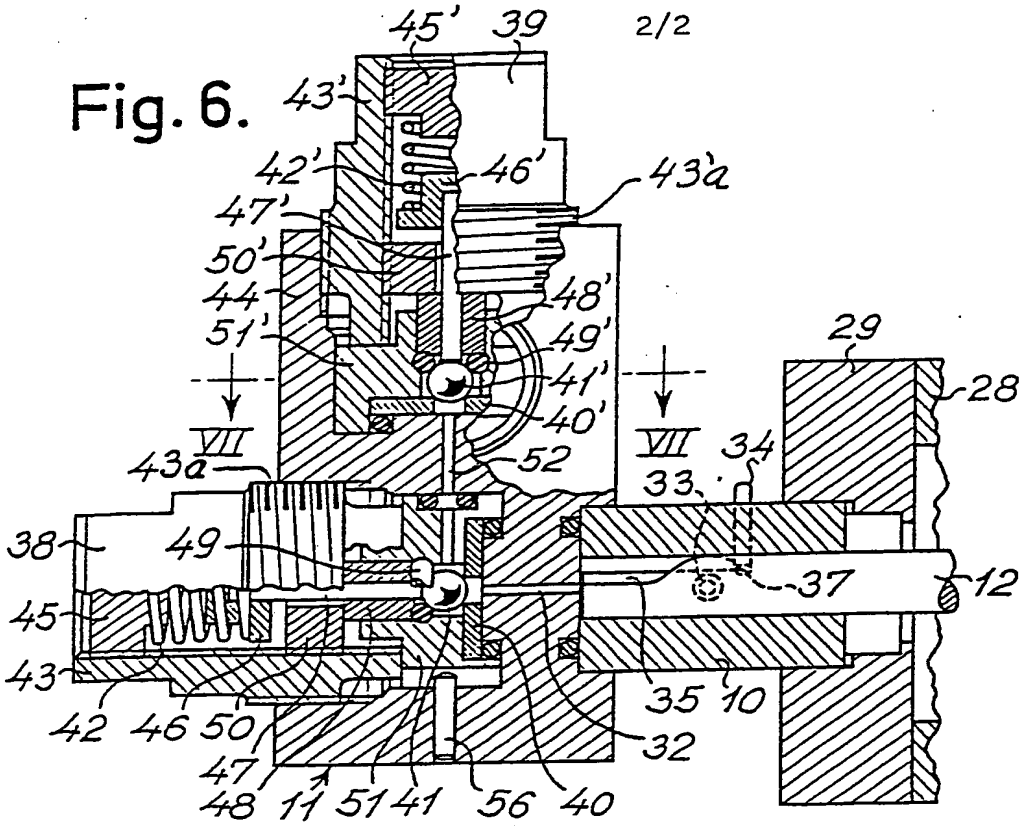



Fig. 7.